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(54) **PROJECTION DEVICE WITH COLOR WHEEL LOCKING FUNCTION AND METHOD USING THE SAME**

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G03B 21/14	(2006.01)
G03B 21/00	(2006.01)
G03B 33/08	(2006.01)

(52) **U.S. Cl.**

CPC ***G02B 26/008*** (2013.01); ***G03B 21/145*** (2013.01); ***G03B 21/206*** (2013.01); *G03B 21/008* (2013.01); *G03B 33/08* (2013.01)

(58) **Field of Classification Search**

CPC G03B 21/14; G03B 21/145; G03B 21/2053; H04N 13/0438; H04N 13/0497; H04N 13/0459

See application file for complete search history.

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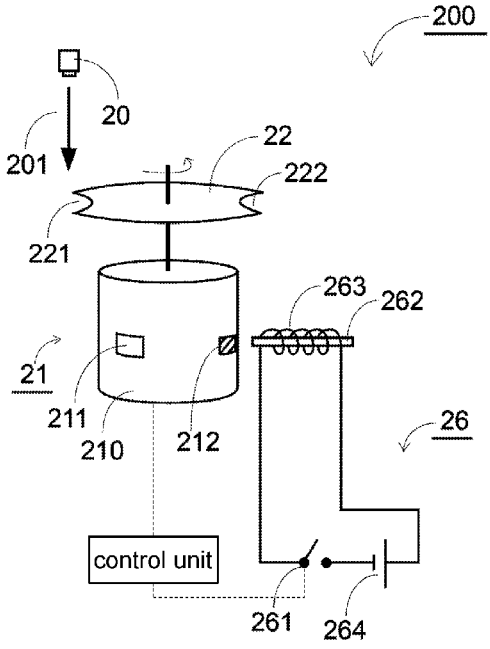
Primary Examiner — Sultan Chowdhury

(57) **ABSTRACT**

A projection device with a color wheel locking function is provided. The projection device includes a light source, a first color wheel unit, a first spindle motor, a magnetic locking mechanism and a control unit. The light source generates a light beam. The first color wheel unit has at least one transparent region through which the light beam transmits. The first spindle motor is to be enabled to rotate the first color wheel unit, and disabled to stop rotating in correspondence with an external magnetic force. The magnetic locking mechanism abuts upon the first spindle motor and generates the external magnetic force. The control unit controls the magnetic locking mechanism. When the first spindle motor stops in correspondence with the external magnetic force, a position of the at least one transparent region corresponds to the light source so that the light beam transmits through the transparent region.

20 Claims, 7 Drawing Sheets



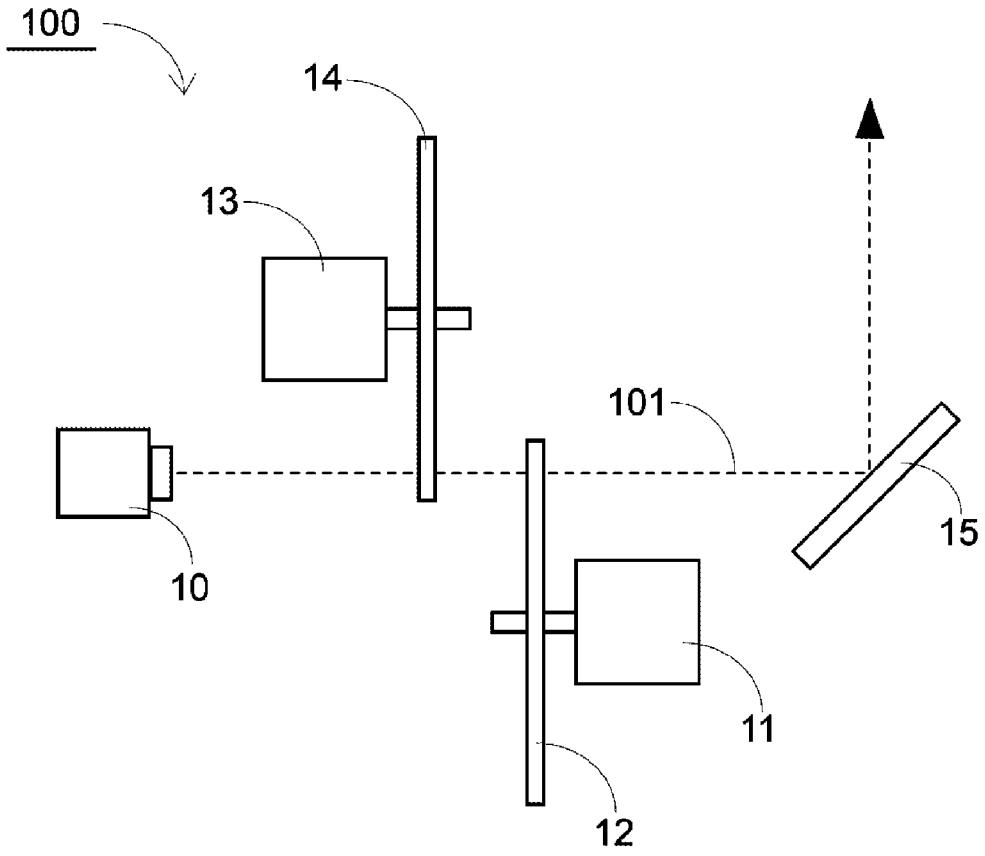


FIG. 1A (Prior Art)

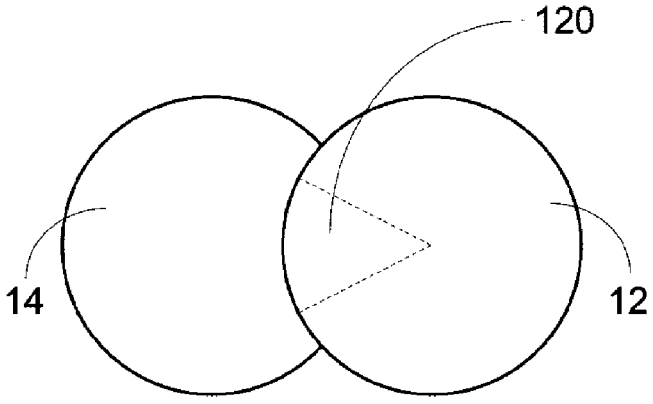


FIG. 1B (Prior Art)

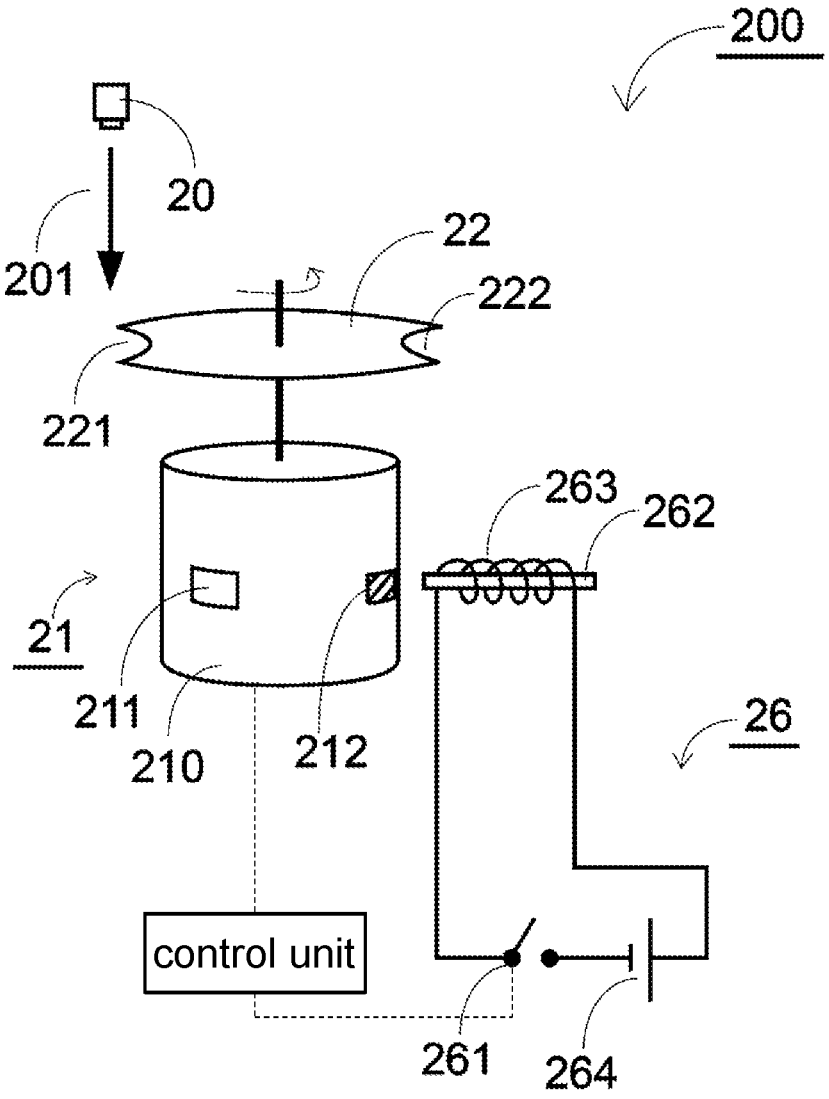

200
20
201
22
222
221
263
262
21
211
210
212
26
control unit
261
264

FIG. 2

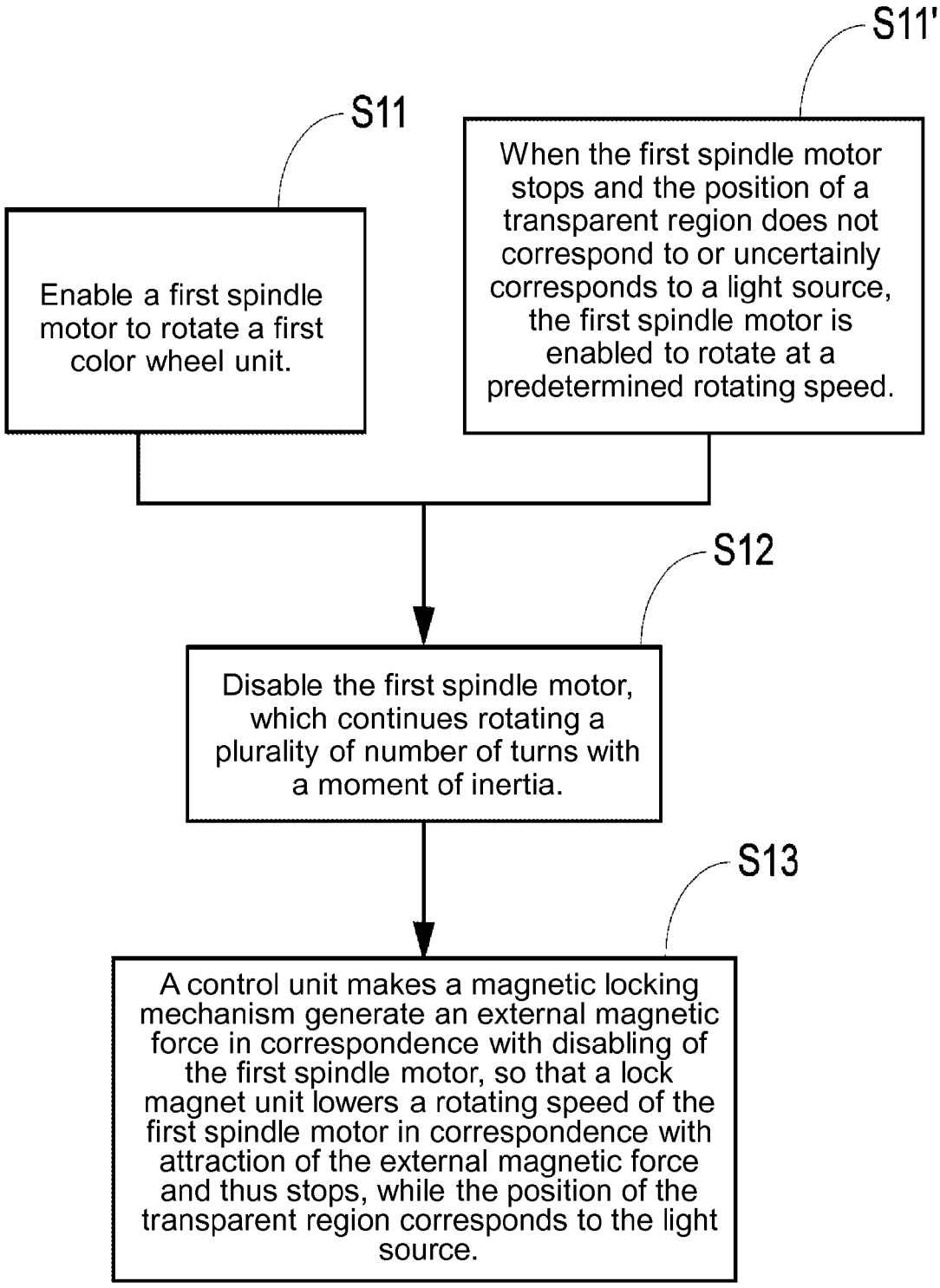

S11
Enable a first spindle motor to rotate a first color wheel unit.
S11'
When the first spindle motor stops and the position of a transparent region does not correspond to or uncertainly corresponds to a light source, the first spindle motor is enabled to rotate at a predetermined rotating speed.
S12
Disable the first spindle motor, which continues rotating a plurality of number of turns with a moment of inertia.
S13
A control unit makes a magnetic locking mechanism generate an external magnetic force in correspondence with disabling of the first spindle motor, so that a lock magnet unit lowers a rotating speed of the first spindle motor in correspondence with attraction of the external magnetic force and thus stops, while the position of the transparent region corresponds to the light source.

FIG. 3

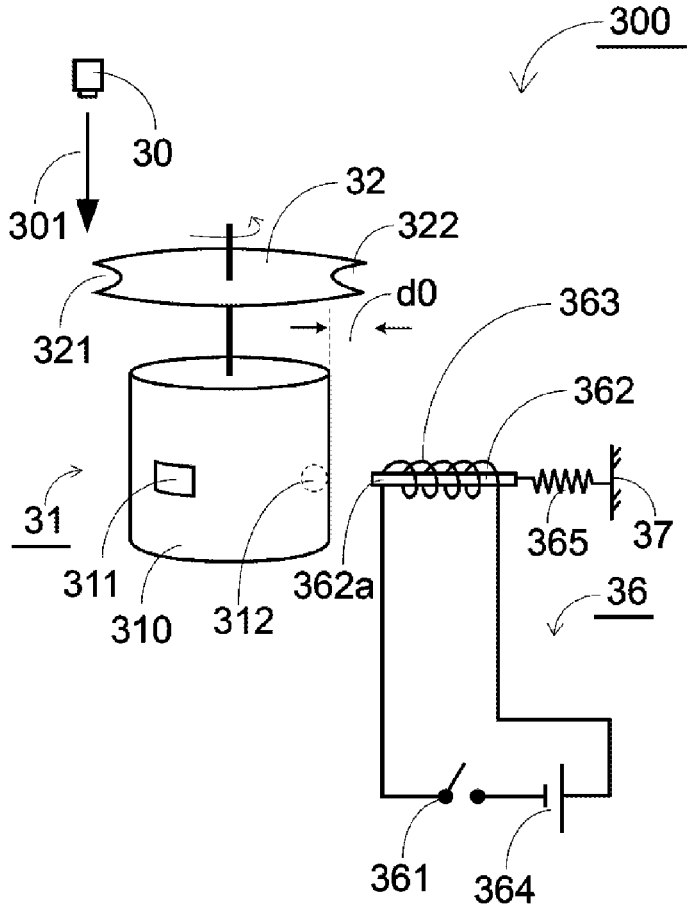

300
30
301
32
322
321
d0
363
362
31
311
310
312
362a
365
37
36
361
364

FIG. 4

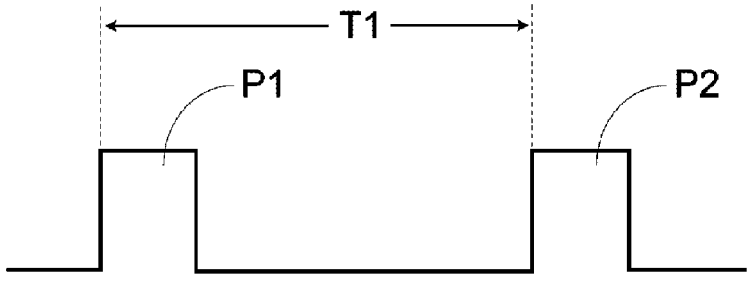

T1
P1
P2

FIG. 5

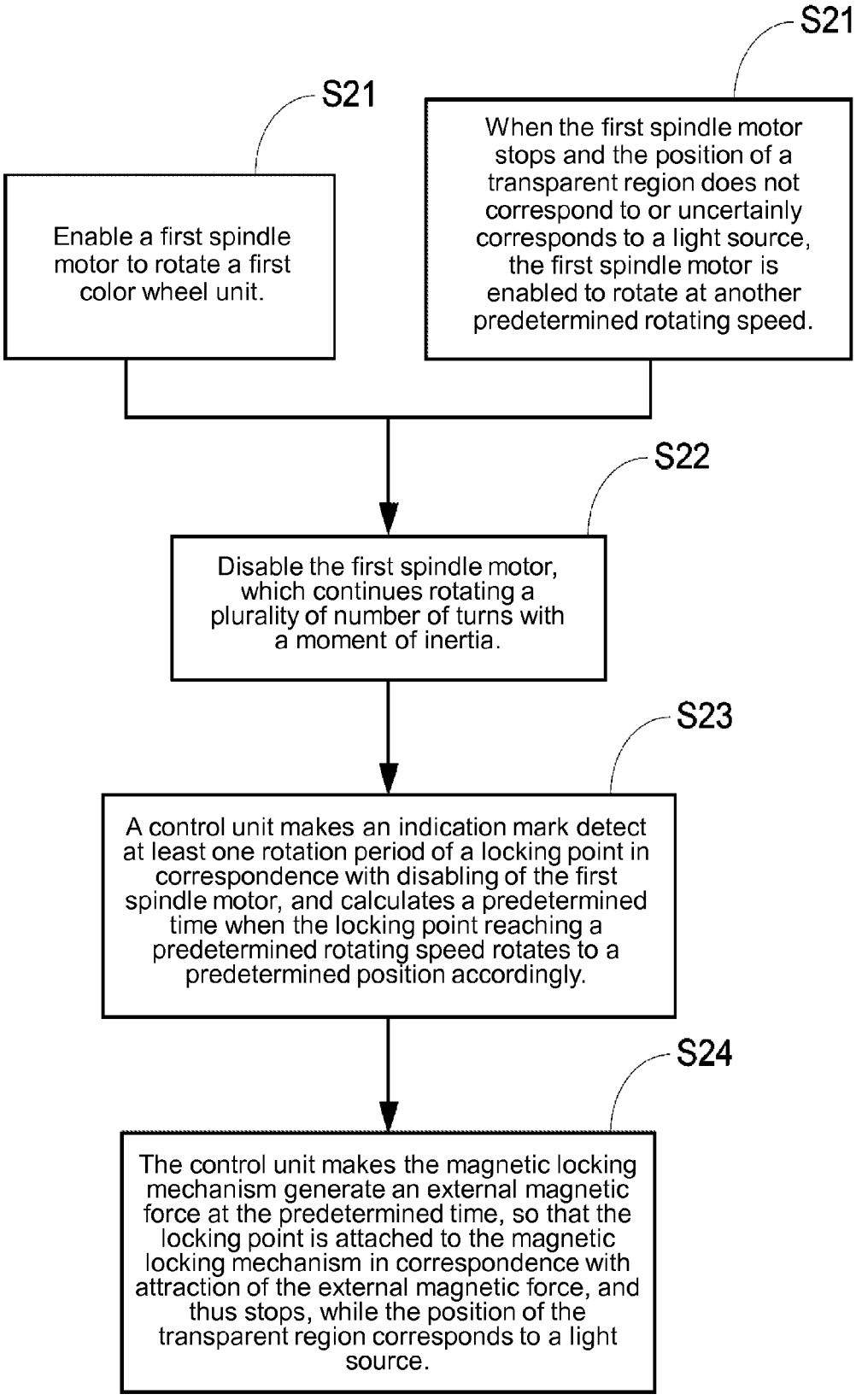

S21
Enable a first spindle motor to rotate a first color wheel unit.
S21'
When the first spindle motor stops and the position of a transparent region does not correspond to or uncertainly corresponds to a light source, the first spindle motor is enabled to rotate at another predetermined rotating speed.
S22
Disable the first spindle motor, which continues rotating a plurality of number of turns with a moment of inertia.
S23
A control unit makes an indication mark detect at least one rotation period of a locking point in correspondence with disabling of the first spindle motor, and calculates a predetermined time when the locking point reaching a predetermined rotating speed rotates to a predetermined position accordingly.
S24
The control unit makes the magnetic locking mechanism generate an external magnetic force at the predetermined time, so that the locking point is attached to the magnetic locking mechanism in correspondence with attraction of the external magnetic force, and thus stops, while the position of the transparent region corresponds to a light source.

FIG. 6

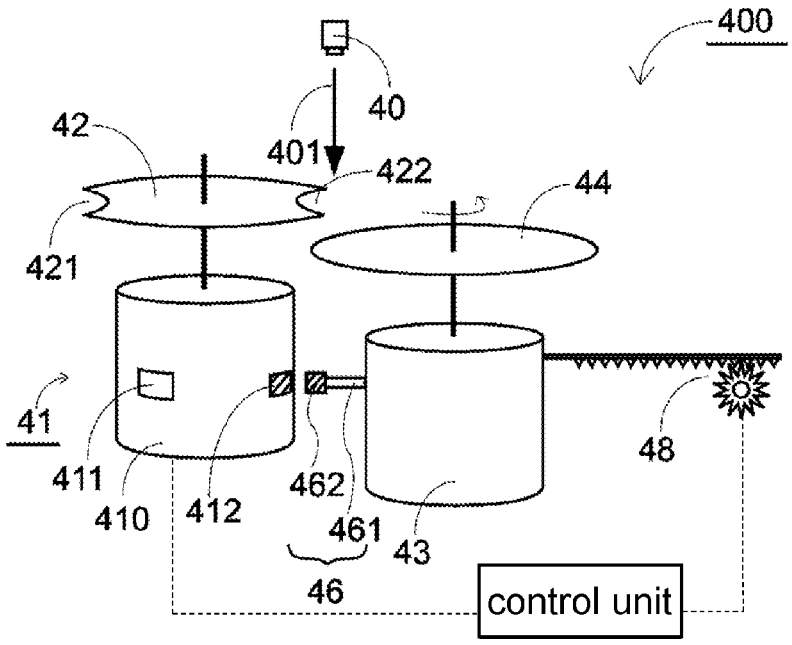

400
40
401
42
422
44
421
41
411
410
412
462
461
43
46
48
control unit

FIG. 7A

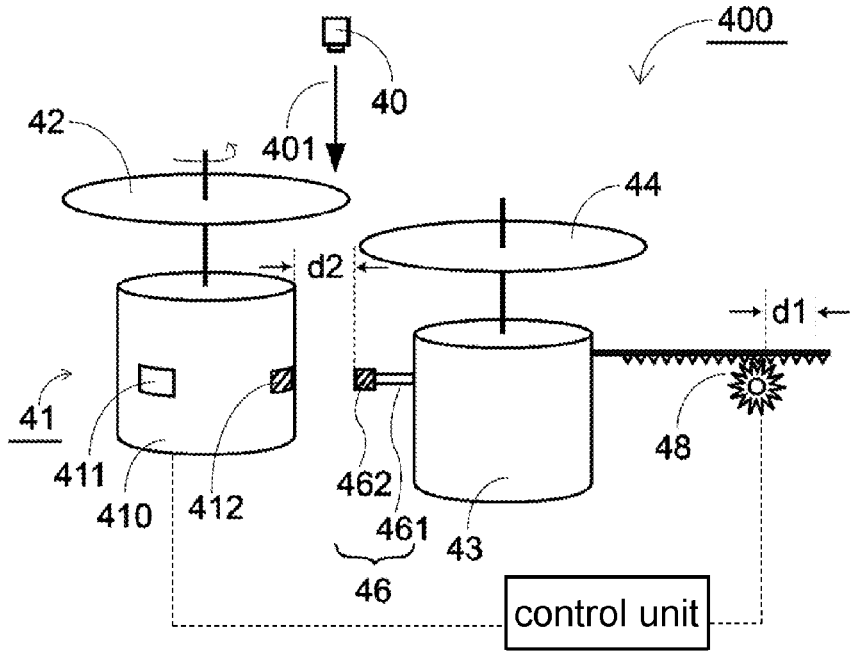

400
40
401
42
44
d2
d1
41
411
410
412
462
461
43
46
48
control unit

FIG. 7B

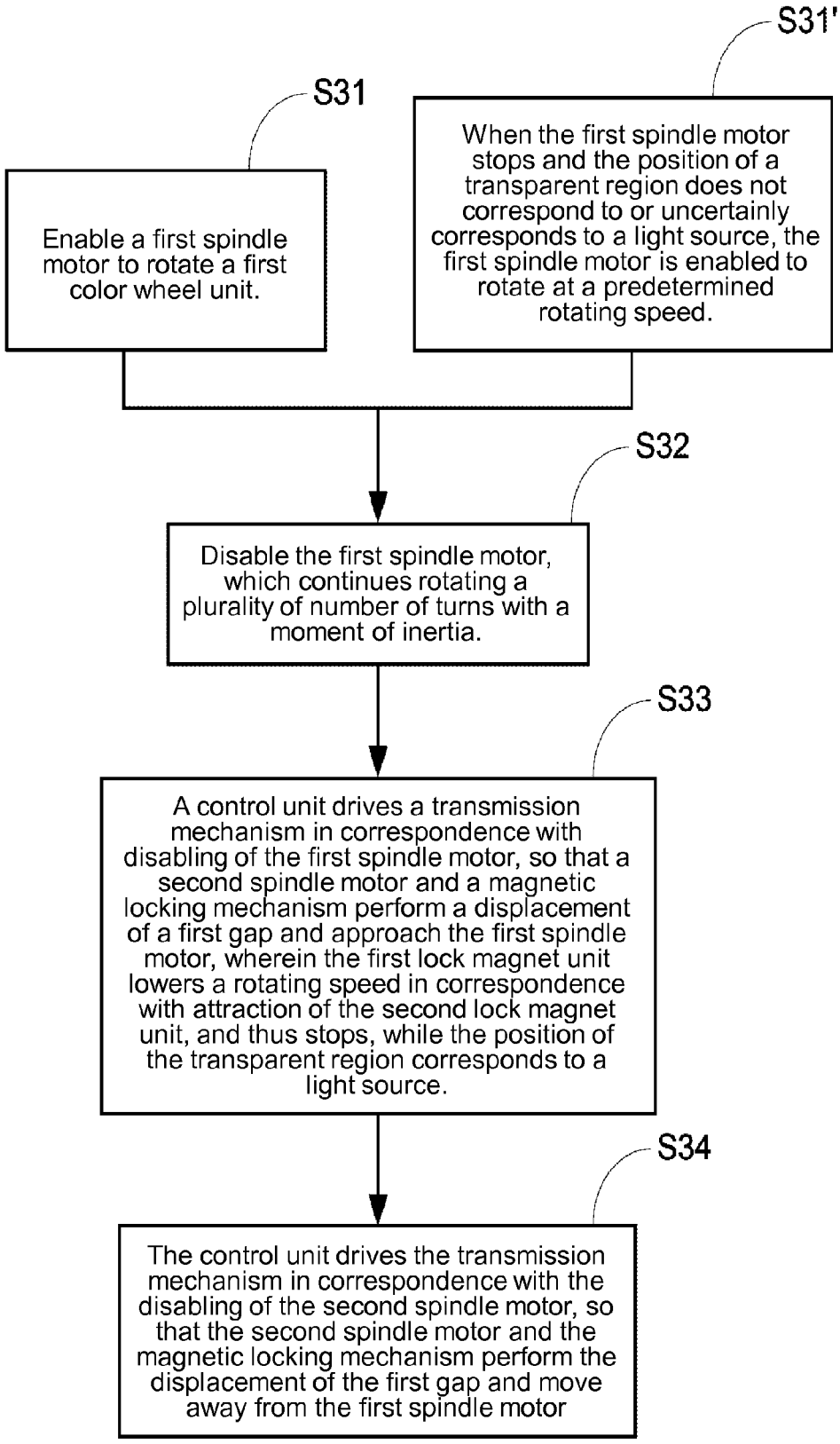

S31
Enable a first spindle motor to rotate a first color wheel unit.
S31'
When the first spindle motor stops and the position of a transparent region does not correspond to or uncertainly corresponds to a light source, the first spindle motor is enabled to rotate at a predetermined rotating speed.
S32
Disable the first spindle motor, which continues rotating a plurality of number of turns with a moment of inertia.
S33
A control unit drives a transmission mechanism in correspondence with disabling of the first spindle motor, so that a second spindle motor and a magnetic locking mechanism perform a displacement of a first gap and approach the first spindle motor, wherein the first lock magnet unit lowers a rotating speed in correspondence with attraction of the second lock magnet unit, and thus stops, while the position of the transparent region corresponds to a light source.
S34
The control unit drives the transmission mechanism in correspondence with the disabling of the second spindle motor, so that the second spindle motor and the magnetic locking mechanism perform the displacement of the first gap and move away from the first spindle motor

FIG. 8

PROJECTION DEVICE WITH COLOR WHEEL LOCKING FUNCTION AND METHOD USING THE SAME

This application claims the benefit of Taiwan application Serial No. 103114505, filed Apr. 22, 2014, the subject matter of which is incorporated herein by reference.

BACKGROUND OF THE INVENTION

1. Field of the Invention

The invention relates in general to a projection device with a color wheel locking function and a method using the same, and more particularly to a device and a method thereof, in which an external magnetic force is provided to lock a spindle motor therein so that a color wheel is locked at a specified position.

2. Description of the Related Art

Most people have the experience of using projectors in conducting either the presentations, conferences or speeches in the occasions of company and seminars, or the video playback in the general family. The applications in conjunction with projectors can provide the viewer excellent presentation and visual effects by way of large-screen projection display.

Generally speaking, the projector uses a color wheel to process a white light beam, generated by a light source and illuminated thereon, into corresponding color light beams for projection. The color wheel is a disk rotatable at a high speed, and has light filtering regions of different colors, wherein the colors usually include red, green and blue colors. That is, the three primary colors of RGB are arranged on the color wheel. By controlling the rotational speed of the disk, different color light beams can be rapidly and continuously emitted. In addition, multiple colors of an image can be generated and presented according to the persistence of vision phenomenon of the human eye.

In addition, to emphasize different applications and projection effects of the projector, different color arrangements on the color wheels may be designed. For example, in the application where the luminance is particularly emphasized, a white or transparent region can be added to the color wheel, so that the light beam illuminating the white or transparent region projects as a color-free light beam. Alternatively, the color wheel is directly designed to have a notch, so that most of the light beams of the light source can transmit through the notch, and the better effects on the presentation of the luminance of the image are obtained.

Alternatively, another color or other colors other than the three primary colors can be added in order to achieve a special color projection effect. However, no matter which application is required, the sizes and the ratios of the regions occupied by various colors are adjusted according to the divided graduations on the disk so as to adjust illuminated time periods of different colors and thus to change the feeling of the human eyes seeing the color of the projected image.

Therefore, in order to achieve the functions of emphasizing the image luminance and color property, the prior art is to dispose two color wheels inside the projector. That is, one color wheel has a notched transparent region, and the other color wheel is an integral disk composed of non-transparent regions.

FIG. **1**A is a schematic view showing an inner structure of a conventional projector **100** having two color wheels. As shown in the drawing, original positions of a first color wheel **12** and a second color wheel **14** partially overlap with each other on an optical path **101** of a light beam generated by a light source **10**. The two color wheels **12** and **14** can be rotated by the spindle motors **11** and **13**, respectively, and the generated light beam can be reflected at various angles through a data plane **15** (may be a reflective DMD) to project the image been seen. The overlapping of the two color wheels **12** and **14** is depicted in FIG. **1**B.

As mentioned hereinabove, one of the color wheels needs to have a mechanical moving function in the projector with two color wheels. As shown in FIGS. **1**A and **1**B, the first color wheel **12** has a transparent region **120**. When the second color wheel **14** needs to operate, the first color wheel **12** is rotated so that its transparent region **120** is disposed on the optical path **101**, and the light beam of the light source **10** can illuminate the second color wheel **14** and transmit through the transparent region **120** without being affected. The second color wheel **14** is designed to have the relative moving structure. When the first color wheel **12** needs to operate, the second color wheel **14** can be moved away from the optical path **101** to avoid interfering with the illuminating light beam.

In other words, if the two color wheels are designed to be movable, then the interference between the two color wheels can be effectively avoided. However, such a design inevitably increases the manufacturing cost and the overall size of the device. Thus, it is an important development direction of such the projector to ensure that each color wheel can be moved to or locked at the correct position under the precondition that only one color wheel is movable.

SUMMARY OF THE INVENTION

The invention is directed to a projection device with a color wheel locking function and a method using the same. In the projection device, an external magnetic force is applied to lock a spindle motor therein, so that its corresponding color wheel is locked at a specified position, thereby effectively avoiding the two color wheels from interfering with each other.

According to a first aspect of the present invention, a projection device with a color wheel locking function is provided. The projection device comprises a light source, a first color wheel unit, a first spindle motor, a magnetic locking mechanism and a control unit. The light source generates a light beam. The first color wheel unit has at least one transparent region through which the light beam transmits. The first spindle motor is to be enabled to rotate the first color wheel unit, and disabled to stop rotating in correspondence with an external magnetic force. The magnetic locking mechanism abuts upon the first spindle motor and generates the external magnetic force. The control unit controls the magnetic locking mechanism. When the first spindle motor stops in correspondence with the external magnetic force, a position of the at least one transparent region corresponds to the light source so that the light beam transmits through the transparent region.

According to a second aspect of the present invention, a color wheel locking method applied to a projection device is provided. The projection device comprises a light source, a first color wheel unit, a first spindle motor, a magnetic locking mechanism and a control unit. The method comprises the steps of: enabling the first spindle motor to rotate the first color wheel unit; disabling the first spindle motor; and enabling the control unit to control the magnetic locking mechanism abutting upon the first spindle motor, so that the first spindle motor stops in correspondence with an external magnetic force generated by the magnetic locking mecha-

nism. When the first spindle motor stops in correspondence with the external magnetic force, a position of a transparent region of the first color wheel unit corresponds to the light source, so that a light beam generated by the light source transmits through the transparent region.

The above and other aspects of the invention will become better understood with regard to the following detailed description of the preferred but non-limiting embodiment(s). The following description is made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1**A is a schematic view showing an inner structure of a conventional projector **100** having two color wheels.

FIG. **1**B is a schematic view showing that the two color wheels **12** and **14** overlap with each other.

FIG. **2** is a schematic view showing an inner structure of a projection device **200** with a color wheel locking function according to the invention.

FIG. **3** is an implementation flow chart showing a color wheel locking method according to a first embodiment of the invention.

FIG. **4** is a schematic view showing an inner structure of a projection device **300** with a color wheel locking function according to the invention.

FIG. **5** shows a diagram of the time versus the signal transmitted by an indication mark **311**.

FIG. **6** is an implementation flow chart showing a color wheel locking method according to a second embodiment of the invention.

FIGS. **7**A and **7**B are schematic views showing an inner structure of a projection device **400** with a color wheel locking function according to the invention.

FIG. **8** is an implementation flow chart showing a color wheel locking method according to a third embodiment of the invention.

DETAILED DESCRIPTION OF THE INVENTION

The embodiments will be described in detail in the following, wherein the embodiments are given for the illustrative purpose only without restricting the claim of the invention. In addition, nonessential elements are omitted from the drawings showing the embodiments so that the technical characteristics of the invention can be clearly described.

The implementation of the invention will be described in the following according to a first embodiment. FIG. **2** is a schematic view showing an inner structure of a projection device **200** with a color wheel locking function according to the invention. Referring to FIG. **2**, the projection device **200** comprises a light source **20**, a first color wheel unit **22**, a first spindle motor **21** and a magnetic locking mechanism **26**. The light source **20** generates a light beam **201** of white light, for example, and the first color wheel unit **22** has at least one transparent region. In this embodiment, the first color wheel unit **22** is configured to have two transparent regions **221** and **222**, which have design of notches. Of course, the first color wheel unit **22** may also be configured into an integral disk and the specified transparent regions are configured as transparent in another embodiment.

In this embodiment, the transparent notches **221** and **222** are configured such that when the transparent notch **221** or **222** is rotated to a position to align with the light source **20**, the light beam **201** can transmit through the transparent notch **221** or **222** correspondingly. Furthermore, the transparent regions **221** and **222** are designed in the form of notches, so the positions of the two transparent regions **221** and **222** are 180-degree symmetrical in order to balance the rotation of the first color wheel unit **22**. That is, the connection line between the two transparent regions **221** and **222** passes through the center of the first color wheel unit **22**.

On the other hand, the first color wheel unit **22** and the first spindle motor **21** in this embodiment cannot move relatively to the light source **20**, and a fixed relative position is present between the magnetic locking mechanism **26** and the first spindle motor **21**. The projection device **200** with the color wheel locking function according to the invention has two color wheels, so the other color wheel unit (not shown in FIG. **2**) needs to have a moving mechanism. The position and the moving mechanism of the second color wheel unit may be the same as those of the prior art, and detailed descriptions thereof will be omitted.

As mentioned hereinabove, the first spindle motor **21** can be enabled (started) to rotate the first color wheel unit **22**. The first spindle motor **21** includes a casing **210**, an indication mark **211** and a lock magnet unit **212**, wherein the indication mark **211** and the lock magnet unit **212** are disposed on the casing **210**.

The indication mark **211** is a position and speed feedback mark (PSM) capable of indicating the transparent regions **221** and **222** by way of signal transmission. This is because the indication mark **211** is also rotated with the rotation of the first spindle motor **21**. Fixed relative positions are present between the indication mark **211** and the transparent regions **221** and **222**. That is, the distances therebetween are fixed to correctly indicate the positions of the transparent regions **221** and **222**. The arrangement of the indication mark **211** pertains to the prior art, and will not be described herein.

One characteristic of the invention resides in that the rotation of the first spindle motor **21** can be stopped in response to an external magnetic force upon being disabled (stopped), and more particularly resides in a mechanism capable of slowing down the rotation and finally completely stopping and locking the motor at a specified position in this embodiment. The external magnetic force is generated by the magnetic locking mechanism **26** abutting upon the first spindle motor **21**. In this embodiment, the magnetic locking mechanism **26** generates the external magnetic force by an electronic magnet. Referring to FIG. **2**, the magnetic locking mechanism **26** may comprise a switch **261**, a core **262**, a coil **263** and a DC power **264**. When the switch **261** is turned on, one end of the core **262** can generate the magnetic field.

Next, the lock magnet unit **212** disposed on the casing **210** is disposed with a magnetic pole, capable of being attracted by the external magnetic force, facing outwards. For example, when the magnetic field generated by one end of the core **262** is S pole, the lock magnet unit **212** is disposed with N pole facing outwards so that the core **262** and the lock magnet unit **212** can be attracted together. In detail, when the first spindle motor **21** is rotating, the lock magnet unit **212** is also rotating therewith, and the position of the magnetic locking mechanism **26** corresponds to the lock magnet unit **212**. In this embodiment, one end of the core **262** is correspondingly disposed to abut upon the rotation track of the lock magnet unit **212**, and a gap capable of effectively generating the magnetic field is present between the core **262** and the lock magnet unit **212**.

Similar to the arrangement of the indication mark **211**, fixed relative positions are also present between the lock magnet unit **212** and the transparent regions **221** and **222**.

That is, the distances therebetween are not changed. In detail, this embodiment is configured such that when one transparent region (the transparent region **221** in FIG. **2**) is aligned with the light source **20**, the lock magnet unit **212** is aligned with the core **262** of the magnetic locking mechanism **26**.

According to the above-mentioned description, it is obtained that another characteristic of this embodiment resides in that the timing of controlling the magnetic locking mechanism **26** to generate the external magnetic force falls on the timing when the first spindle motor **21** is disabled (i.e., stopped); and that when the first spindle motor **21** is enabled (i.e., started) to rotate, the magnetic locking mechanism **26** does not generate the external magnetic force. Thus, the projection device **200** further comprises a control unit, which is electrically connected to the first spindle motor **21** (or the indication mark **211**) and the magnetic locking mechanism **26**, and controls the magnetic locking mechanism **26** (i.e., controls the switch **261** to turn on or off) according to the enabled/disabled state of the first spindle motor **21**.

In other words, the control unit controls the magnetic locking mechanism **26** to generate the external magnetic force in response to the disabled state of the first spindle motor **21**. Because the first spindle motor **21** is switched from the operating state to the non-operating state when the first spindle motor **21** is still rotating, when the first spindle motor **21** is disabled, it still has a moment of inertia and thus can continue rotating a plurality of number of turns. Thus, the lock magnet unit **212** can pass through the front of the core **262** of the magnetic locking mechanism **26** more than once. That is, when the switch **261** is turned on, the lock magnet unit **212** will lower down the overall rotating speed in correspondence with the continuous attraction of the external magnetic force. When its rotating speed is lowered down to a specific value, the lock magnet unit **212** can not escape form the external magnetic force and thus stops.

When the first spindle motor **21** stops in correspondence with the external magnetic force, the lock magnet unit **212** is aligned with the core **262** of the magnetic locking mechanism **26**, thereby achieving the locking at the specified position. With the design of the relative position, the position of one transparent region **221** corresponds to the light source **20**, so that the light beam **201** can transmit therethrough. Furthermore, when the first spindle motor **21** is again enabled and switched to the rotating state, the magnetic locking mechanism **26** stops generating the external magnetic force.

The above-mentioned embodiment is described with reference to the locking of the first spindle motor **21** under the rotating condition of the normal operation. However, when the first spindle motor **21** of the projection device **200** is in the non-operating state, the transparent region **221** (or **222**) may not be aligned with the light source **20**. For example, when the projection device **200** is just turned on and does not perform the above-mentioned process, or the external magnetic force has stopped, so that the transparent regions **221** and **222** on the first color wheel unit **22** may be offset, and the light beam **201** is blocked and cannot transmit therethrough.

Accordingly, this embodiment further has another mechanism, in which when the first spindle motor **21** stops, and the position of one transparent region **221** (or **222**) does not correspond thereto or uncertainly corresponds thereto (e.g., stopped and then started), the first spindle motor **21** is enabled to rotate at a predetermined rotating speed first to make the first spindle motor **21** enter the rotating state. This predetermined rotating speed may be the relative low rotating speed, which is different from the rotating speed generated by the first spindle motor **21** enabled when the first color wheel unit **22** is in the normal operation. Then, the first spindle motor **21** is again disabled, so that the magnetic locking mechanism **26** can lock the lock magnet unit **212** at the specified position as mentioned hereinabove, to make the position of the transparent region **221** correspond to the light source **20**.

FIG. **3** is an implementation flow chart showing a color wheel locking method applied to the projection device **200** according to the first embodiment of the invention. First, the first spindle motor **21** is enabled to rotate the first color wheel unit **22** (step **S11**). Next, the first spindle motor **21** is disabled, and the first spindle motor **21** continues rotating a plurality of number of turns by the moment of inertia (step **S12**). Then, the control unit makes the magnetic locking mechanism **26** generate the external magnetic force in correspondence with the disabling of the first spindle motor **21**, so that the lock magnet unit **212** lowers the rotating speed in correspondence with the attraction of the external magnetic force, and thus stops, while the position of one transparent region **221** corresponds to the light source **20** (step **S13**).

As mentioned hereinabove, the first embodiment may also start from another step. That is, when the first spindle motor **21** stops and the position of its transparent region does not correspond to or uncertainly corresponds to the light source **20**, the first spindle motor **21** is enabled to rotate at a predetermined rotating speed (step **S11'**). The subsequent implementation flow can similarly enter the steps **S12** to **S13**.

The invention may further be correspondingly modified according to the concepts disclosed in the first embodiment, so that the similar effects and implementations can be achieved under the similar structure design.

A second embodiment of the invention will be described in the following. FIG. **4** is a schematic view showing an inner structure of a projection device **300** with a color wheel locking function according to the invention, wherein the similar references relate to the similar elements. As shown in FIG. **4**, the difference of this embodiment resides in that a lock magnet unit is not disposed on the first spindle motor **31**. Instead, a casing **310** made of a metallic or paramagnetic material is provided, and a locking point **312** thereon is set and to be attracted by the external magnetic force.

Although the lock magnet unit **212** in the first embodiment has the more significant effect of being attracted by the magnetic force as compared with the ambient casing **210**, it still has a predetermined weight to affect the overall balance and cause the damage upon the rotation of the color wheel. Thus, the cost is increased to add the symmetrical balancing counterbalance. The main characteristic of the second embodiment is to directly adopt the casing **310** as an object to be attracted; and more particularly is to provide a mechanism capable of immediately stopping the rotation of the first spindle motor **31** once a magnetic locking mechanism **36** generates an external magnetic force, and capable of locking the locking point **312** at the specified position.

Similarly, the fixed relative positions are also present between the indication mark **311**, the locking point **312** and the transparent regions **321** and **322**, and the first color wheel unit **32** and the first spindle motor **31** also cannot be moved relatively to the light source **30**. However, as shown in FIG. **4**, the core **362** of the magnetic locking mechanism **36** is movable relatively to the first spindle motor **31**. It can be obtained that another characteristic of this embodiment also

resides in the timing of controlling the magnetic locking mechanism **36** to generate the external magnetic force, but the generating timing does not fall on the timing when the first spindle motor **31** is disabled.

FIG. **5** shows a diagram of the time versus the signal transmitted by the indication mark **311**. As shown in FIG. **5**, a time length between a first signal P**1** and a second signal P**2** represents the rotation period T**1** when the first spindle motor **31** rotates one turn. That is, a signal is outputted when the indication mark **311** rotates one turn. In this embodiment, the first spindle motor **31** being still rotating is similarly switched from the operating state to the non-operating state. Thus, the first spindle motor **31** still has a moment of inertia when being disabled, and thus can continue rotating a plurality of number of turns. Under the moment of inertia, the subsequent rotation will slow down gradually, the period is lengthened, and the lengthening trend can be calculated.

In addition, the indication mark **311** can indicate the relative position of the locking point **312** (similar to the lock magnet unit **212** of the first embodiment), so the locking point **312** or the displacement trend of an arbitrary point on the first spindle motor **31** can be obtained by way of calculation. Thus, the control unit of this embodiment makes the indication mark **311** detect at least one rotation period of the locking point **312** in correspondence with the disabling of the first spindle motor **31**. It is preferred to detect multiple rotation periods and compare the front and rear periods with each other to obtain its changing trend.

Next, the control unit calculates a predetermined time when the locking point **312** reaching a predetermined rotating speed rotates to a predetermined position according to the obtained rotation period. In detail, the predetermined position is disposed in front of the core **362** of the magnetic locking mechanism **36**; and the predetermined rotating speed is a relative low rotating speed, which is different from the rotating speed generated by the first spindle motor **31** enabled when the first color wheel unit **32** is in the normal operation. The predetermined rotating speed (may be equal to or approximate to the predetermined rotating speed in the step S**11**' of the previous example) is mainly determined according to the magnitude of the external magnetic force, which can be generated by the magnetic locking mechanism **36** to ensure that the first spindle motor **31** can be immediately stopped upon the generation of the external magnetic force.

Thereafter, the control unit makes the magnetic locking mechanism **36** generate the external magnetic force at the predetermined time, so that the set locking point **312** can be correctly attracted. The locking point **312** is attached to the core **362** of the magnetic locking mechanism **36** in correspondence with the attraction of the external magnetic force, and thus stops.

On the other hand, the magnetic locking mechanism **36** further comprises a spring **365**, which has one end disposed on the core **362**, and the other end disposed on a fixing surface **37**. In this embodiment, a gap d**0** is present between the core **362** and the locking point **312** before the external magnetic force is generated. After the external magnetic force is generated, attracting condition of the core **362** to the locking point **312** moves the core **362** so that one end **362***a* thereof is attached to the locking point **312**.

As mentioned hereinabove, in correspondence with the rotating speed (may be the predetermined rotating speed) of the locking point **312** or the magnitude of the external magnetic force, the displacement of the core **362** may be larger than or equal to the gap d**0**. Furthermore, the property of the spring **365** can generate the resilient deformation in correspondence with the displacement of the core **362**, and pulls the locking point **312** and the core **362** back to the specified positions. Thus, when the locking point **312** is locked at the specified position, the position of the transparent region **321** corresponds to the light source **30**.

FIG. **6** is an implementation flow chart showing a color wheel locking method applied to the projection device **300** according to a second embodiment of the invention. First, the first spindle motor **31** is enabled to rotate the first color wheel unit **32** (step S**21**). Next, the first spindle motor **31** is disable, and the first spindle motor **31** continues rotating a plurality of number of turns by the moment of inertia (step S**22**). Then, the control unit makes the indication mark **311** detect at least one rotation period of the locking point **312** in correspondence with the disabling of the first spindle motor **31**, and calculates a predetermined time when the locking point **312** reaching a predetermined rotating speed rotates to a predetermined position (step S**23**) according to the at least one rotation period. Thereafter, the control unit makes the magnetic locking mechanism **36** generate the external magnetic force at the predetermined time, so that the locking point **312** is attached to the magnetic locking mechanism **36** in correspondence with the attraction of the external magnetic force, and thus stops. Meanwhile, a position of the transparent region **321** corresponds to the light source **30** (step S**24**).

Similarly, the second embodiment may also start from another step. That is, when the first spindle motor **31** stops and the position of its transparent region does not correspond to or uncertainly corresponds to the light source **30**, the first spindle motor **31** is enabled to rotate at another predetermined rotating speed (step S**21**'). The subsequent implementation flow can similarly enter the steps S**22** to S**24**.

A third embodiment of the invention will be described in the following. FIGS. **7**A and **7**B are schematic views showing an inner structure of a projection device **400** with a color wheel locking function according to the invention, wherein the similar references relate to the similar elements. In FIGS. **7**A and **7**B, the projection device **400** further comprises a second color wheel unit **44**, a second spindle motor **43** and a transmission mechanism **48**. FIG. **7**A schematically shows the operation of the second color wheel unit **44**, while FIG. **7**B schematically shows the operation of a first color wheel unit **42**.

The second spindle motor **43** can be enabled (i.e., started) to rotate the second color wheel unit **44**, and the transmission mechanism **48** is mechanically coupled to the second spindle motor **43** and a magnetic locking mechanism **46**, so that the second color wheel unit **44**, the second spindle motor **43** and the magnetic locking mechanism **46** can move integrally. That is, the second color wheel unit **44** and the second spindle motor **43** can move to the positions shown in FIG. **7**A or **7**B through the transmission. In detail, as shown in FIG. **7**A, the second color wheel unit **44** approaches the first color wheel unit **42**, but the light beam **401** of the light source **40** can transmit through a transparent region **422** and illuminate the second color wheel unit **44**. As shown in FIG. **7**B, the second color wheel unit **44** is away from the first color wheel unit **42** to prevent the interference of the light beam **401** when the light beam **401** illuminates the first color wheel unit **42**.

In this embodiment, a first spindle motor **41** is similar to the first embodiment, and a first lock magnet unit **412** is disposed on the casing **410**, wherein fixed relative positions are present between the first lock magnet unit **412** and the

transparent regions **421** and **422**. The difference of this embodiment mainly resides in that the magnetic locking mechanism **46** adopts a second lock magnet unit **462** to generate the external magnetic force, and the second lock magnet unit **462** can move. In detail, the magnetic locking mechanism **46** of this embodiment further comprises a fixing frame **461**. As shown in FIG. **7**A, the fixing frame **461** is mechanically coupled to the second spindle motor **43**, and the second lock magnet unit **462** is disposed on the fixing frame **461**. In order to generate the mutual attraction, the second lock magnet unit **462** and the first lock magnet unit **412** are disposed with different poles abutting upon each other.

In this embodiment, the second lock magnet unit **462** directly generating the magnetic force is used to replace the electronic magnet designs in the above-mentioned two embodiments. In the projection device with two color wheels, the moving mechanism is essential. So, this embodiment directly utilizes the moving mechanism to make the magnetic force of the magnet unit generate the influence, so that the manufacturing cost can be further saved, and the size of the overall device can be reduced.

In this embodiment, the control unit can drive the transmission mechanism **48** (a stepping motor, a gear and a guiding rod can be adopted to perform the transmission) in correspondence with the disabled state (i.e., stopped state) of the first spindle motor **41**, so that the second spindle motor **43** and the magnetic locking mechanism **46** perform the displacement of a first gap d**1** and approach the first spindle motor **41** (i.e., move from the position of FIG. **7**B leftwards to the position of FIG. **7**A). In the schematic view of FIG. **7**B, the first spindle motor **41** is enabled to rotate the first color wheel unit **42**, and a second gap d**2** is present between the first lock magnet unit **412** and the second lock magnet unit **462**. The second gap d**2** needs to be configured such that the first lock magnet unit **412** and the second lock magnet unit **462** cannot attract each other to move. That is, the first lock magnet unit **412** is disposed outside the affecting range of the external magnetic force generated by the second lock magnet unit **462**.

On the other hand, the control unit can drive the transmission mechanism **48** in correspondence with the disabled state (i.e., stopped state) of the second spindle motor **41**, so that the second spindle motor **43** and the magnetic locking mechanism **46** perform the displacement of the first gap d**1** and move away from the first spindle motor **41** (i.e., move from the position of FIG. **7**A rightwards to the position of FIG. **7**B), so that the subsequent rotation of the first color wheel unit **42** does not cause interference. In this embodiment, the second gap d**2** is configured to be larger than the first gap d**1**, so that the second lock magnet unit **462** is not attached to the first lock magnet unit **412** but only generates the continuous attraction action in the schematic view of FIG. **7**A.

In other words, the external magnetic force of this embodiment is continuously generated, but the affecting range thereof is controlled by way of driving and transmission methods in correspondence with the disabling of the first spindle motor **41**. Similarly, the first spindle motor **41** being still rotating is switched from the operating state to the non-operating state (from the schematic view of FIG. **7**B to that of FIG. **7**A), so the first spindle motor **41** still has a moment of inertia upon being disabled, and can thus continue rotating a plurality of number of turns. Thus, the first lock magnet unit **412** can pass the front of the second lock magnet unit **462** more than once by way of rotation. That is, the first lock magnet unit **412** will slow down the overall rotating speed in correspondence with the continuous attraction of the external magnetic force. When its rotating speed is slowed down to a certain specific value, the first lock magnet unit **412** cannot escape from the external magnetic force and thus stops.

When the first spindle motor **41** stops in correspondence with the external magnetic force, the first lock magnet unit **412** will be aligned with the second lock magnet unit **462**, thereby achieving the object of locking the second lock magnet unit **462** at the specified position. According to the design of the relative position, the position of one transparent region **422** corresponds to the light source **40**, so that the light beam **401** can transmit through the transparent region **422**.

FIG. **8** is an implementation flow chart showing a color wheel locking method applied to the projection device **400** according to a third embodiment of the invention. First, the first spindle motor **41** is enabled to rotate the first color wheel unit **42** (step S**31**). Next, the first spindle motor **41** is disabled, and the first spindle motor **41** continues rotating a plurality of number of turns by the moment of inertia (step S**32**). Then, the control unit drives the transmission mechanism **48** in correspondence with the disabling of the first spindle motor **41**, so that the second spindle motor **43** and the magnetic locking mechanism **46** perform the displacement of a first gap d**1** and approach the first spindle motor **41**. The first lock magnet unit **412** slows down the rotating speed in correspondence with the attraction of the second lock magnet unit **462**, and thus stops. Meanwhile, a position of a transparent region **422** corresponds to the light source **40** (step S**33**).

In addition, if the first spindle motor **41** is to be again enabled to switch to the operating rotating state, then the flow of this embodiment further comprises the following step. The control unit drives the transmission mechanism **48** in correspondence with the disabling of the second spindle motor **43**, so that the second spindle motor **43** and the magnetic locking mechanism **46** perform the displacement of the first gap d**1** and move away from the first spindle motor **41** (step S**34**).

Similarly, the third embodiment may also start from another step. That is, when the first spindle motor **41** stops and the position of its transparent region does not correspond to or uncertainly corresponds to the light source **40**, the first spindle motor **41** is enabled to rotate at a predetermined rotating speed (step S**31'**). The subsequent implementation flow can similarly enter the steps S**32** to S**34**.

In summary, for the projection device having two color wheels, the idea of the invention can make each color wheel be moved to be locked to the correct position in the corresponding operation in order to prevent the interference of the projected light beam. In addition, it is also possible to design one set of the color wheel and the motor to move, and the other set is relatively fixed. That is, the invention can effectively save the manufacturing cost and reduce the size of the overall device.

Therefore, the invention can effectively solve the associated problems mentioned in the prior art, and can successfully achieve the main object of this application.

While the invention has been described by way of example and in terms of the preferred embodiment(s), it is to be understood that the invention is not limited thereto. On the contrary, it is intended to cover various modifications and similar arrangements and procedures, and the scope of the appended claims therefore should be accorded the broadest interpretation so as to encompass all such modifications and similar arrangements and procedures.

What is claimed is:

1. A projection device with a color wheel locking function, the projection device comprising:

a light source generating a light beam;

a first color wheel unit having at least one transparent region through which the light beam transmits;

a first spindle motor to be enabled to rotate the first color wheel unit, and disabled to stop rotating in correspondence with an external magnetic force;

a magnetic locking mechanism abutting upon the first spindle motor and generating the external magnetic force; and

a control unit controlling the magnetic locking mechanism;

wherein when the first spindle motor stops in correspondence with the external magnetic force, a position of the at least one transparent region corresponds to the light source so that the light beam transmits through the at least one transparent region.

2. The projection device according to claim 1, wherein the first spindle motor comprises:

a casing;

an indication mark, which is disposed on the casing and indicates a rotating speed and the position of the transparent region; and

a lock magnet unit disposed on the casing with a magnetic pole, capable of attracting the external magnetic force, facing outwards, wherein fixed relative positions are present between the transparent region and both the indication mark and the lock magnet unit.

3. The projection device according to claim 2, wherein the magnetic locking mechanism generates the external magnetic force by an electronic magnet, a fixed relative position is present between the magnetic locking mechanism and the first spindle motor, and a position of the magnetic locking mechanism corresponds to the lock magnet unit.

4. The projection device according to claim 2, wherein the control unit makes the magnetic locking mechanism generate the external magnetic force in correspondence with disabling of the first spindle motor.

5. The projection device according to claim 4, wherein the first spindle motor has a moment of inertia upon being disabled, and thus continues rotating a plurality of number of turns, and the lock magnet unit lowers the rotating speed in correspondence with attraction of the external magnetic force and thus stops.

6. The projection device according to claim 1, wherein the first spindle motor comprises:

a casing, which is made of a metallic or paramagnetic material, and has a locking point to be attracted by the external magnetic force; and

an indication mark, which is disposed on the casing and indicating a rotating speed and the position of the transparent region, and fixed relative positions are present between the transparent region and both the indication mark and the locking point.

7. The projection device according to claim 6, wherein the magnetic locking mechanism generates the external magnetic force by an electronic magnet, and the magnetic locking mechanism comprises:

a core, wherein a gap is present between the core and the locking point before the external magnetic force is generated, and the core performs a displacement larger than or equal to the gap and is attached to the locking point after the external magnetic force is generated; and

a spring, which has one end disposed on the core and the other end disposed on a fixing surface, and generates resilient deformation in correspondence with the displacement of the core.

8. The projection device according to claim 6, wherein the first spindle motor has a moment of inertia upon being disabled, and thus continues rotating a plurality of number of turns, and the control unit makes the indication mark detect at least one rotation period of the locking point in correspondence with disabling of the first spindle motor.

9. The projection device according to claim 8, wherein the control unit calculates a predetermined time when the locking point reaching a predetermined rotating speed rotates to a predetermined position according to the rotation period, and makes the magnetic locking mechanism generate the external magnetic force at the predetermined time.

10. The projection device according to claim 9, wherein the predetermined position is disposed in front of the magnetic locking mechanism, and the locking point is attached to the magnetic locking mechanism in correspondence with attraction of the external magnetic force and thus stops.

11. The projection device according to claim 1, wherein the first spindle motor comprises:

a casing; and

a first lock magnet unit, which is disposed on the casing and is attracted by the external magnetic force, wherein a fixed relative position is present between the first lock magnet unit and the transparent region.

12. The projection device according to claim 11, wherein the projection device comprises:

a second color wheel unit to be illuminated by the light beam;

a second spindle motor to be enabled to rotate the second color wheel unit; and

a transmission mechanism mechanically coupled to the second spindle motor and the magnetic locking mechanism;

wherein the control unit drives the transmission mechanism in correspondence with disabling of the first spindle motor so that the second spindle motor and the magnetic locking mechanism perform a displacement of a first gap and approach the first spindle motor; and the control unit drives the transmission mechanism in correspondence with disabling of the second spindle motor, so that the second spindle motor and the magnetic locking mechanism perform the displacement of the first gap and move away from the first spindle motor.

13. The projection device according to claim 12, wherein the magnetic locking mechanism comprises:

a fixing frame mechanically coupled to the second spindle motor; and

a second lock magnet unit, which is disposed on the fixing frame and generates the external magnetic force, wherein the second lock magnet unit and the first lock magnet unit are disposed with different poles abutting upon each other;

wherein when the first spindle motor is enabled, a second gap is present between the first lock magnet unit and the second lock magnet unit such that the first lock magnet unit and the second lock magnet unit do not attract each other, wherein the second gap is larger than the first gap.

14. The projection device according to claim 12, wherein the first spindle motor has a moment of inertia upon being disabled, and thus continues rotating a plurality of number of turns, and the first lock magnet unit lowers a rotating

speed in correspondence with attraction of the external magnetic force, and thus stops.

15. The projection device according to claim **1**, wherein when the first spindle motor stops and a position of the at least one transparent region does not correspond to or uncertainly corresponds to the light source, the first spindle motor is enabled to rotate at a predetermined rotating speed, and then the first spindle motor is disabled.

16. A color wheel locking method applied to a projection device, the projection device comprising a light source, a first color wheel unit, a first spindle motor, a magnetic locking mechanism and a control unit, the method comprising the steps of:

enabling the first spindle motor to rotate the first color wheel unit;

disabling the first spindle motor; and

enabling the control unit to control the magnetic locking mechanism abutting upon the first spindle motor, so that the first spindle motor stops in correspondence with an external magnetic force generated by the magnetic locking mechanism;

wherein when the first spindle motor stops in correspondence with the external magnetic force, a position of a transparent region of the first color wheel unit corresponds to the light source, so that a light beam generated by the light source transmits through the transparent region.

17. The method according to claim **16**, wherein the first spindle motor comprises a lock magnet unit, and the method further comprises the steps, in which:

the first spindle motor continues rotating a plurality of number of turns in correspondence with a moment of inertia of the first spindle motor upon being disabled;

the control unit makes the magnetic locking mechanism generate the external magnetic force in correspondence with disabling of the first spindle motor; and

the lock magnet unit lowers a rotating speed of the first spindle motor in correspondence with attraction of the external magnetic force, and thus stops.

18. The method according to claim **16**, wherein the first spindle motor comprises an indication mark and a locking point made of a metallic or paramagnetic material, and the method further comprises the steps, in which:

the first spindle motor continues rotating a plurality of number of turns in correspondence with a moment of inertia of the first spindle motor upon being disabled;

the control unit makes the indication mark detect at least one rotation period of the locking point in correspondence with disabling of the first spindle motor;

the control unit calculates a predetermined time when the locking point reaching a predetermined rotating speed rotates to a predetermined position according to the rotation period, and makes the magnetic locking mechanism generate the external magnetic force at the predetermined time; and

the locking point is attached to the magnetic locking mechanism in correspondence with attraction of the external magnetic force, and thus stops;

wherein the predetermined position is disposed in front of the magnetic locking mechanism.

19. The method according to claim **16**, wherein the first spindle motor comprises a first lock magnet unit, the projection device comprises a second spindle motor and a transmission mechanism, the magnetic locking mechanism comprises a second lock magnet unit generating the external magnetic force, the transmission mechanism is mechanically coupled to the second spindle motor and the magnetic locking mechanism, and the method further comprises the steps, in which:

the first spindle motor continues rotating a plurality of number of turns in correspondence with a moment of inertia of the first spindle motor upon being disabled;

the control unit drives the transmission mechanism in correspondence with disabling of the first spindle motor, so that the second spindle motor and the magnetic locking mechanism perform a displacement of a first gap and approach the first spindle motor;

the first lock magnet unit lowers a rotating speed in correspondence with attraction of the second lock magnet unit, and thus stops; and

the control unit drives the transmission mechanism in correspondence with disabling of the second spindle motor, so that the second spindle motor and the magnetic locking mechanism perform the displacement of the first gap and move away from the first spindle motor.

20. The method according to claim **16**, wherein the method further comprises the steps of:

enabling the first spindle motor to rotate at a predetermined rotating speed when the first spindle motor stops and the position of the transparent region does not correspond to or uncertainly corresponds to the light source; and

disabling the first spindle motor.

* * * * *